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SEA TEST PERFORMANCE OF A REAL TIME LINEAR CORRELATOR.(U)
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TECHNICAL NOTE

SEA TEST PERFORMANCE OF A REAL TIME LINEAR CORRELATOR

Contract Number NObsr-93140

Project Serial No. SS041-001,
Task 8100, Task 10899

28 June 1965

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SEA TEST PERFORMANCE OF A REAL TIME LINEAR CORRELATOR

Summary

The results of a sea test of the TRACOR 3-bit real time linear correlator have been analyzed. The performance of this processor is compared to that of the shipboard clipped correlator and a 12-bit simulated linear correlator. The analysis clearly demonstrates the superiority of the linear correlator over the clipped correlator. Comparison of the 3-bit linear correlator sea test data to the data obtained from the 12-bit simulated correlator indicates that further improvements in the performance of the 3-bit linear correlator could probably be achieved by adjustment of some system parameters. On the basis of this analysis it is recommended that a linear correlator be utilized in the signal processor for the AN/SQS-26.

Analysis

Signal-to-noise ratio calculations were carried out on the outputs of the three correlators, and the results are plotted in Figures 1, 2, and 3. Figure 1 is a plot of S/N out of the 3-bit linear correlator vs S/N out of the clipped correlator. Figure 2 is a plot of S/N out of the 3-bit linear correlator vs S/N out of the simulated 12-bit correlator. Figure 3 is a plot of S/N out of the clipped correlator vs S/N out of the simulated 12-bit correlator.

Any lack of normalization present in the output of the linear correlator would show up as time variations in the mean and standard deviation of the output noise. In order to insure that any performance degradation due to lack of normalization is included in the results of this analysis, the means and standard deviations used in the calculations were obtained from a large sample of noise in the annulus of interest. This was accomplished

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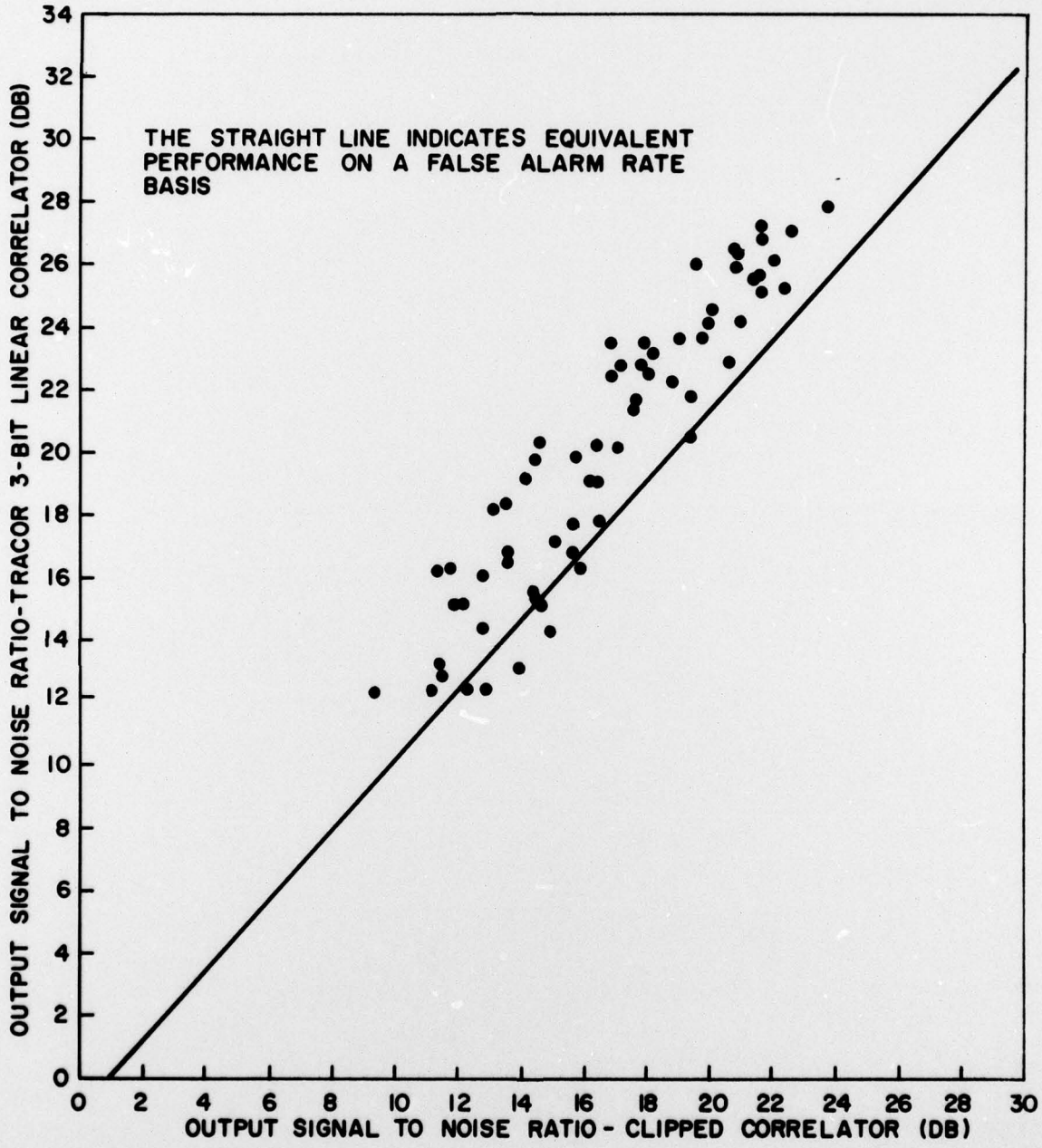

FIG. 1 - OUTPUT SIGNAL TO NOISE RATIO FROM THE TRACOR 3-BIT LINEAR CORRELATOR VS OUTPUT SIGNAL TO NOISE RATIO FROM THE CLIPPED CORRELATOR

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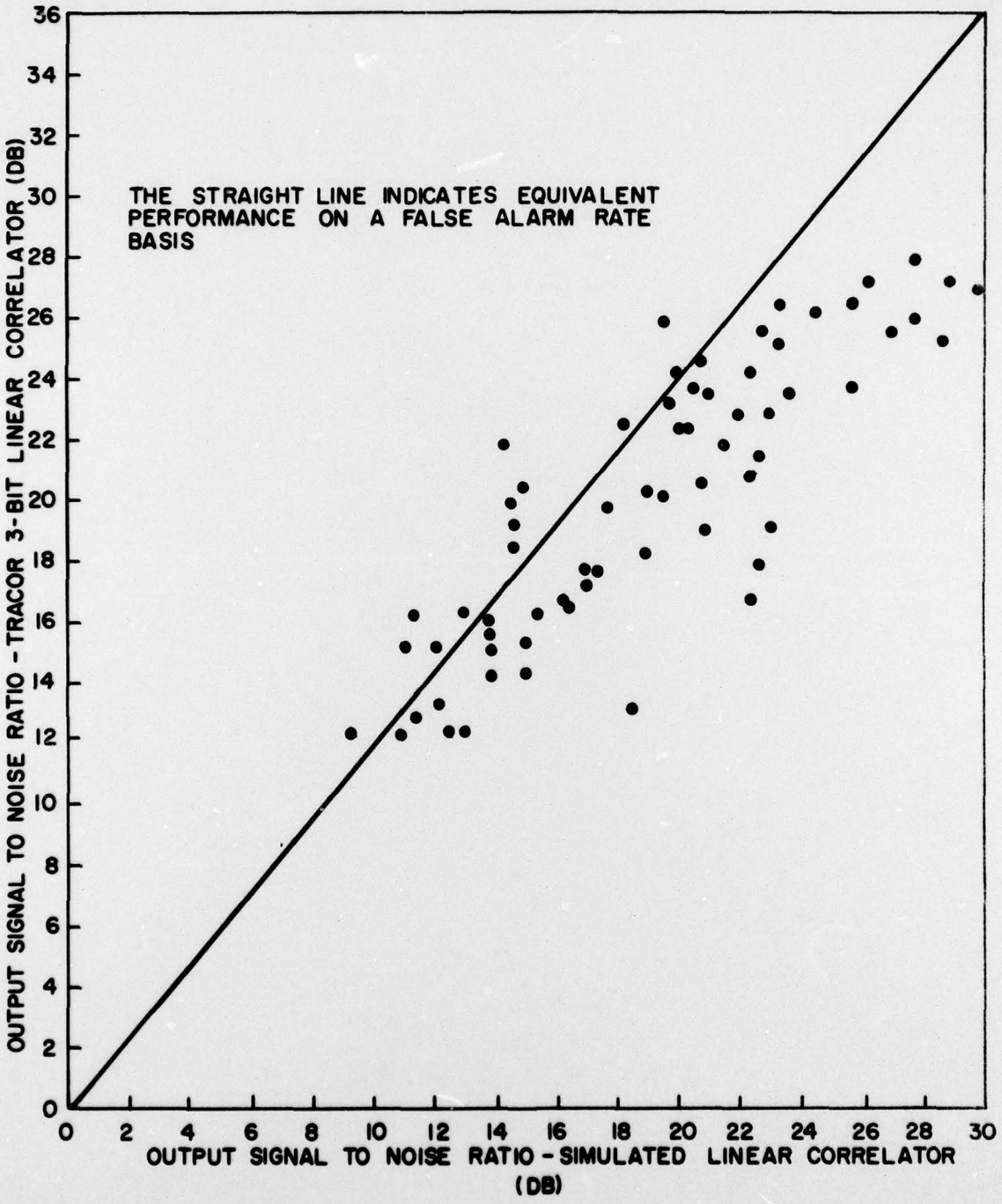

FIG. 2 -OUTPUT SIGNAL TO NOISE RATIO FROM THE TRACOR 3-BIT LINEAR CORRELATOR VS OUTPUT SIGNAL TO NOISE RATIO FROM THE SIMULATED LINEAR CORRELATOR

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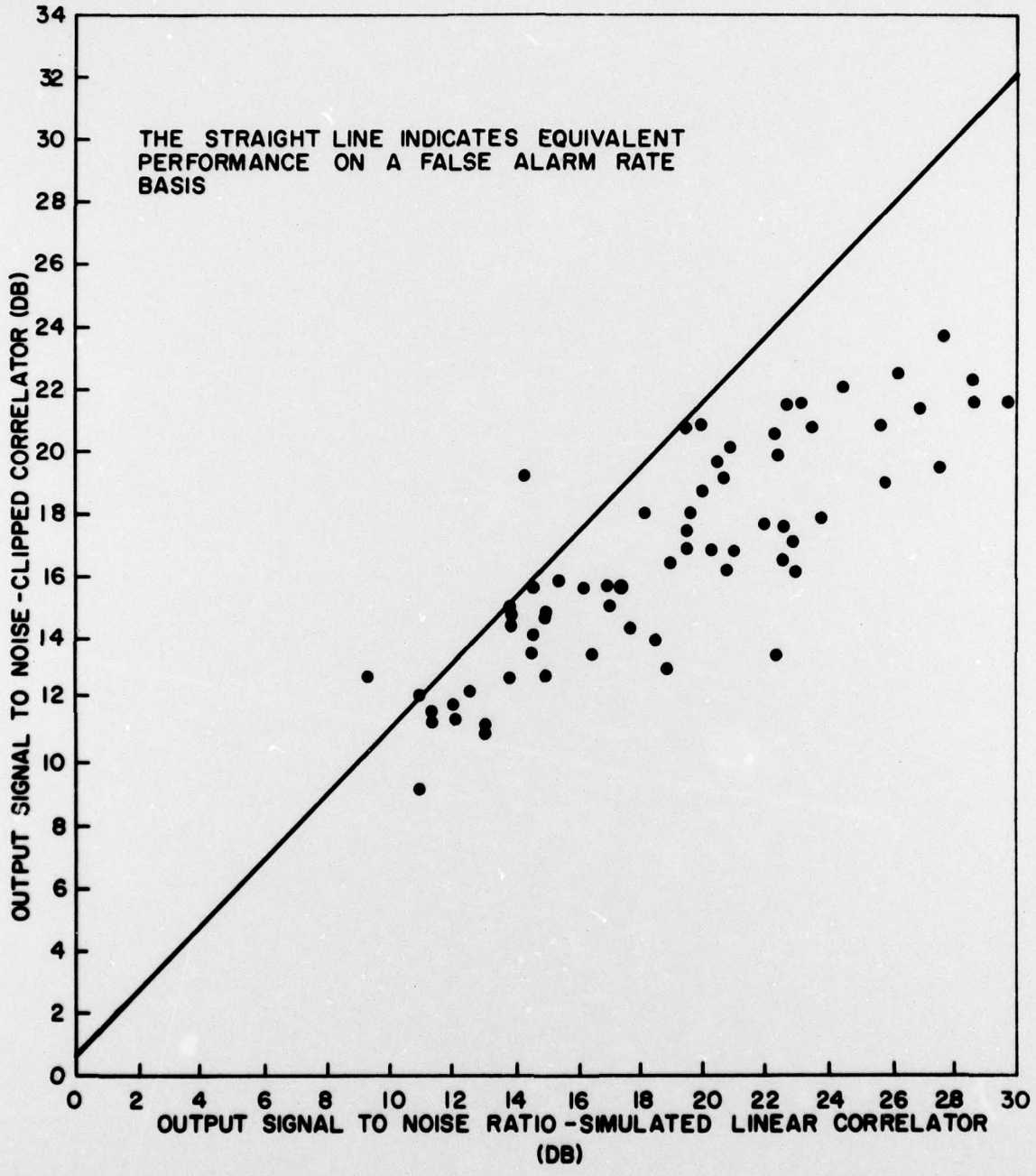

FIG. 3 -OUTPUT SIGNAL TO NOISE RATIO FROM THE CLIPPED CORRELATOR VS OUTPUT SIGNAL TO NOISE RATIO FROM THE SIMULATED LINEAR CORRELATOR

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by extracting samples of the output noise of each processor from several echo cycles in each sea test data run. The mean and standard deviation for that run were then determined by carrying out a statistical analysis on the resulting noise samples. The statistical distributions from each correlator were virtually identical for all data runs used. From these distributions, curves were obtained which give "Probability of Exceeding Threshold" vs "Threshold Setting."

It is well known from information theory that a waveform having a finite bandwidth β contains 2β independent samples per second or β complex samples per second. Since all phase information is destroyed in the envelope detector which follows the correlators, only β independent amplitude samples per second remain in the output from the detector. This output bandwidth for the three processors under consideration is 100 cps. Thus by multiplying the probability of exceeding the threshold by 100, plots of "Rate of Exceeding Threshold" vs "Threshold Setting" are obtained for the three processors. These curves are shown in Figure 4.

The differences in the three curves of Figure 4 are attributed to slight non-linearities in the response of the rectifiers of both the shipboard correlators. The discrepancies are explainable if the hardware rectifiers are operating with a power law slightly greater than unity. By comparing the threshold settings for the three processors at various values of "Rate of Exceeding Threshold" equivalent performance points are obtained. The threshold values were converted to dB and plotted on Figures 1, 2, 3 resulting in the straight lines shown on the graphs. These lines then represent equivalent performance of the processors on an equal "False Alarm Rate" basis. Since the rectifier of the simulated correlator is absolutely linear, the slopes of the lines on Figures 2 and 3 may be interpreted as approximate values of the power laws applicable to the rectifiers in the 3-bit linear

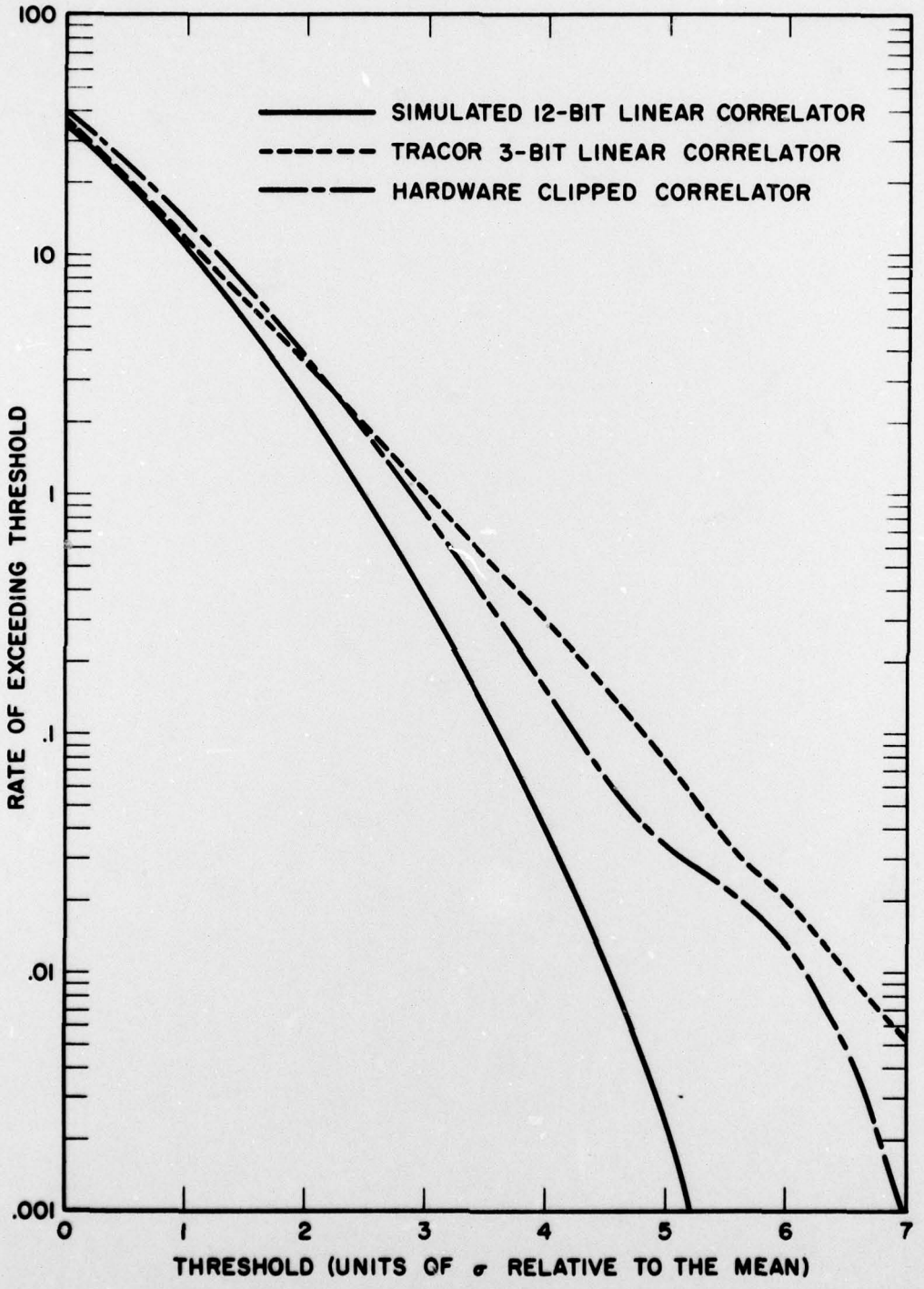

FIG. 4 – RATE OF EXCEEDING THRESHOLD VS THRESHOLD SETTING

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correlator and the clipped correlator respectively. These slopes are 1.2 and 1.05 respectively. This lack of linearity does not influence performance of the system since increases in output rate of threshold crossing are compensated by increased signal-to-noise ratios. With the equivalent performance lines, Figures 1-3 indicate that the performance of the TRACOR 3-bit linear correlator falls between that of the other two processors.

In order to obtain a clearer comparison of the correlators "Modified ROC Curves" (Rate of Exceeding Threshold vs Probability of Detection) are obtained for the three processors. An additional set of curves must first be obtained. These curves are plots of "Threshold Setting" vs "Probability of Detection." To obtain these curves the output peak signal values (in units of noise standard deviation relative to the noise mean) which were measured from each correlator were rank ordered with the largest first. The i'th sample of this set was plotted vs i/N where N is the total number of data points for each correlator. This technique yields the curves shown in Figure 5.

Figures 4 and 5 may be used to map the modified ROC curves. The procedure to obtain each point on the curve is as follows.

1) Pick a value of "Rate of Exceeding Threshold."
2) From Figure 4 look up the corresponding threshold.
3) Using this threshold, look up the corresponding "Probability of Detection" on Figure 5.

The resulting 'Modified ROC Curves" are shown in Figure 6. These curves show clearly that the 3-bit linear correlator out performs the clipped correlator. Past simulation studies, however, indicate that a much closer agreement between the 3-bit and 12-bit linear correlators should be achieved. The data seem to indicate that clipping was occurring in the 3-bit linear correlator for lower signal levels than expected. This could be caused by improper setting of the conversion levels in the analog-to-digital

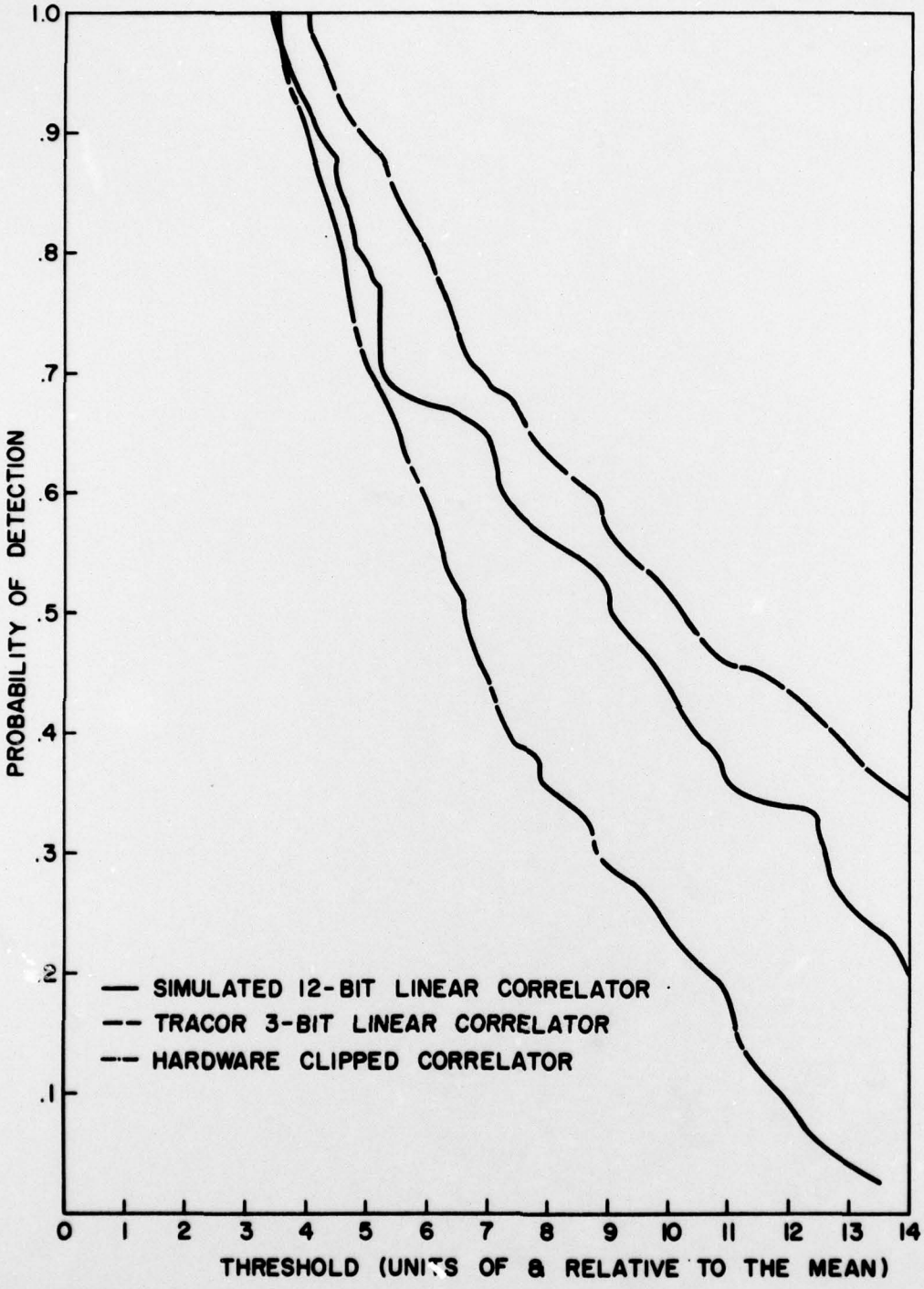

FIG. 5 - PROBABILITY OF DETECTION VS THRESHOLD SETTING

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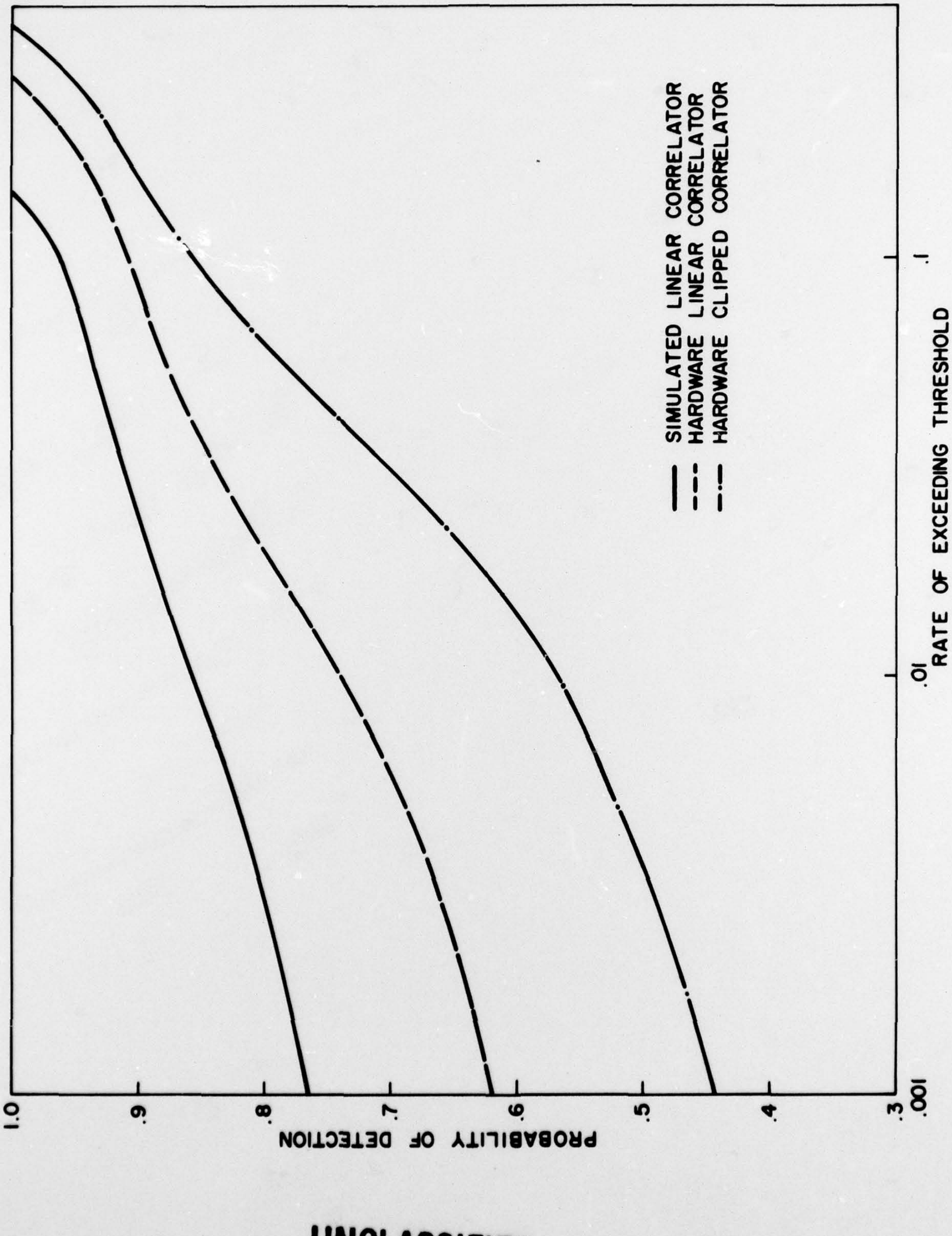

FIG. 6 - PROBABILITY OF DETECTION VS FALSE ALARM RATE

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converter[1]. It thus seems quite possible that the 3-bit linear correlator would perform still better with the proper adjustment of this threshold.

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[1]TRACOR Summary Report II, TRACOR Document Number 64-290-C, p. 146.